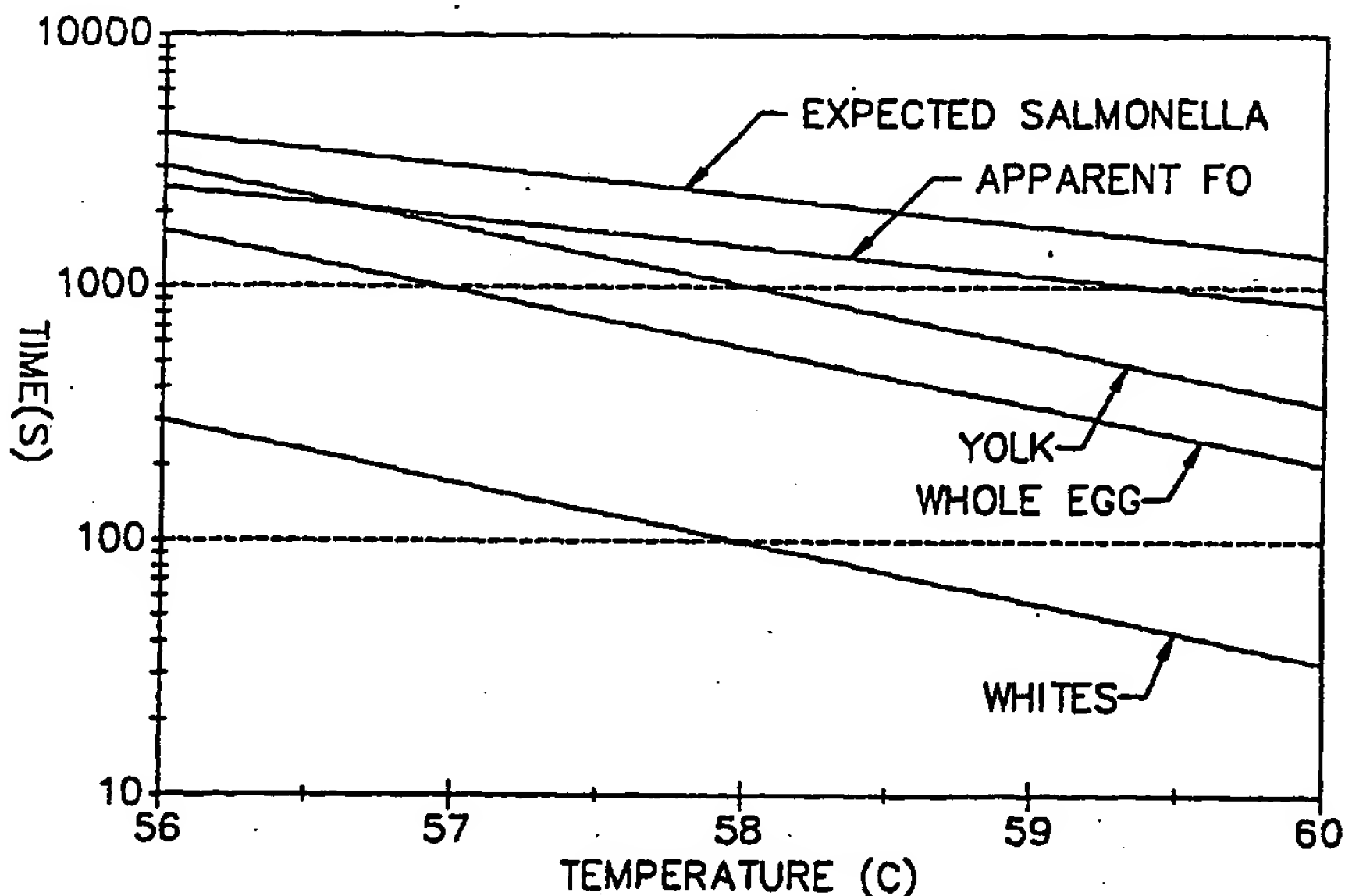




## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification <sup>6</sup> : <b>A23B 5/005</b>		<b>A1</b>	(11) International Publication Number: <b>WO 95/18538</b>
			(43) International Publication Date: <b>13 July 1995 (13.07.95)</b>
(21) International Application Number: <b>PCT/US95/00254</b> (22) International Filing Date: <b>3 January 1995 (03.01.95)</b> (30) Priority Data: <b>178,734</b> <b>7 January 1994 (07.01.94)</b> <b>US</b> (60) Parent Application or Grant (63) Related by Continuation <b>US</b> <b>178,734 (CON)</b> Filed on <b>7 January 1994 (07.01.94)</b> (71) Applicant (for all designated States except US): <b>UNIVERSITY OF MISSOURI SYSTEM AT COLUMBIA [US/US]; 509 Lewis Hall, Columbia, MO 65211 (US).</b> (72) Inventors; and (75) Inventors/Applicants (for US only): <b>VANDEPOPULIERE, Joseph, M. [US/US]; 211 Green Meadows Circle, Columbia, MO 65203 (US). COTTERILL, Owen, J. [US/US]; 1030 Westwinds Court, Columbia, MO 65203 (US).</b> (74) Agents: <b>SIBLEY, Kenneth, D. et al.; Bell, Seltzer, Park &amp; Gibson, P.O. Drawer 34009, Charlotte, NC 28234 (US).</b>		(81) Designated States: <b>AM, AT, AU, BB, BG, BR, BY, CA, CH, CN, CZ, DE, DK, EE, ES, FI, GB, GE, HU, JP, KE, KG, KP, KR, KZ, LK, LR, LT, LU, LV, MD, MG, MN, MW, MX, NL, NO, NZ, PL, PT, RO, RU, SD, SE, SI, SK, TJ, TT, UA, US, UZ, VN, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG), ARIPO patent (KE, MW, SD, SZ).</b>  <b>Published</b> <i>With international search report.</i> <i>Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i>	

(54) Title: METHOD OF REDUCING SALMONELLA IN SHELL EGGS



## (57) Abstract

The present invention relates to producing a safer shell egg through thermal treatment. The present invention provides methods of producing a shell egg wherein the albumen and the yolk of the shell egg receives a thermal treatment sufficient to pasteurize the shell egg and thereby combat the risk of salmonella. The present invention provides methods of providing thermal treatments to the shell egg through introduction of the shell egg into an aqueous solution of a predetermined temperature and maintaining the shell egg in the solution for a predetermined time sufficient to cause the required reduction in salmonella. The predetermined times and temperatures may be characterized by use of the equivalent point method of thermal evaluation, by use of the  $F_0$  line for shell egg or by other methods of determining the reduction in salmonella.

**FOR THE PURPOSES OF INFORMATION ONLY**

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	GB	United Kingdom	MR	Mauritania
AU	Australia	GE	Georgia	MW	Malawi
BB	Barbados	GN	Guinea	NE	Niger
BE	Belgium	GR	Greece	NL	Netherlands
BF	Burkina Faso	HU	Hungary	NO	Norway
BG	Bulgaria	IE	Ireland	NZ	New Zealand
BJ	Benin	IT	Italy	PL	Poland
BR	Brazil	JP	Japan	PT	Portugal
BY	Belarus	KE	Kenya	RO	Romania
CA	Canada	KG	Kyrgyzstan	RU	Russian Federation
CF	Central African Republic	KP	Democratic People's Republic of Korea	SD	Sudan
CG	Congo	KR	Republic of Korea	SE	Sweden
CH	Switzerland	KZ	Kazakhstan	SI	Slovenia
CI	Côte d'Ivoire	LI	Liechtenstein	SK	Slovakia
CM	Cameroon	LK	Sri Lanka	SN	Senegal
CN	China	LU	Luxembourg	TD	Chad
CS	Czechoslovakia	LV	Latvia	TG	Togo
CZ	Czech Republic	MC	Monaco	TJ	Tajikistan
DE	Germany	MD	Republic of Moldova	TT	Trinidad and Tobago
DK	Denmark	MG	Madagascar	UA	Ukraine
ES	Spain	ML	Mali	US	United States of America
FI	Finland	MN	Mongolia	UZ	Uzbekistan
FR	France			VN	Viet Nam
GA	Gabon				

## Method of reducing Salmonella in shell eggs

### Field of the Invention

The present invention relates to methods for pasteurizing shell eggs. More particularly the present invention relates to methods for reducing or  
5 eliminating salmonella from shell eggs and for improving the storage capabilities of shell eggs.

### Background of the Invention

It is well known that salmonella organisms have been associated with egg products. More recently,  
10 *Salmonella enteritidis* (SE) has been detected within shell eggs. Presently, the presence of salmonella within the shell egg is a major concern. Some states have enacted legislation preventing the serving of unpasteurized egg products unless fully cooked. In  
15 fact, since as early as 1969, the USDA has overseen the processing of liquid egg removed from the shell to reduce the level of salmonella contamination to acceptable levels. However, no commercially acceptable methods have been developed to combat salmonella in  
20 shell eggs. Since shell eggs must be used in situations where a liquid egg product cannot, it is therefore desirable to develop a commercially acceptable process for the reduction of salmonella within shell eggs to provide a safe and functionally  
25 acceptable shell egg to the consumer.

-2-

Thermal treatments of shell egg to prevent embryonic growth in fertile eggs, to reduce incidence of spoilage during long term storage, and maintain internal quality received considerable research  
5 attention from about 1943 to about 1953. This research resulted from the nature of the egg industry at that time in that most of the eggs were produced by small flocks and the majority of the eggs used by the food industry were collected as seasonal surpluses in the  
10 spring. As a result of the production practices the eggs were more likely to lose interior quality or become unfit for human consumption because of bacterial growth or embryonic development. Research into "thermostabilization" was directed at solving these  
15 problems, which were largely perceived as embryonic growth and the contamination of the egg from contaminants external to the shell. (See Egg Science, Chapter 4, 3d Ed., 1986).

U.S. Patent No. 2,423,233 to Funk describes  
20 the thermostabilization of shell eggs. The '233 patent described a process of heating the shell egg to arrest embryonic development in the egg. As described in the '233 patent, when heating with water the preferred times and temperatures for the heat treatment were 138  
25 degrees Fahrenheit for from five to ten minutes. However, the work of Dr. Funk was not concerned with the elimination of pathogenic organisms. In fact, the times and temperatures suggested by Dr. Funk for heating with water would not be sufficient to cause  
30 high enough levels of SE destruction to insure that a safe shell egg would result. Furthermore, because eggs available through modern production and distribution are fresher and have a lower pH they require a different thermal process than was used by Funk.

35 Accordingly, it is one object of the present invention to provide a safe shell egg product which is

-3-

essentially free of salmonella and more preferably free of *Salmonella enteritidis*.

It is another object of the present invention to provide a commercially acceptable process for  
5 reducing the levels of SE in shell eggs to acceptable levels.

It is still a further object of the present invention to provide a method of producing a salmonella negative shell egg without requiring additional thermal  
10 treatments which could reduce the functionality of the shell egg.

#### Summary of the Invention

The present invention provides methods for producing a pasteurized shell egg while retaining the  
15 normal appearance of the shell egg contents. The present invention, therefore, relates to a commercially viable method of producing a pasteurized shell egg. One particular embodiment of the present invention involves heating the shell egg in an aqueous solution  
20 of a predetermined temperature for a predetermined time. The heating at a predetermined time for a predetermined temperature provide to the albumen of the shell egg a total thermal treatment which can be described by an equivalent time and an equivalent  
25 temperature which define a point above the "whites 9D salmonella line" of Figure 1 but is insufficient to cause coagulation of either the albumen or the yolk of the shell egg.

In another aspect of the present invention  
30 the equivalent time and equivalent temperature define a point above the yolk 9D salmonella line of Figure 1, but again insufficient to cause coagulation of either the albumen or the yolk of the shell egg.

Another aspect of the present invention  
35 involves heating the shell egg in an aqueous solution of a predetermined temperature and maintaining the

-4-

shell in the aqueous solution for a predetermined time, wherein the predetermined time and the predetermined temperature provide to the albumen of the shell egg a thermal treatment sufficient to cause a 9D reduction in *S. enteritidis* but insufficient to cause coagulation of the albumen or the yolk of the shell egg. A further aspect of this embodiment involves providing a thermal treatment sufficient to cause a 9D reduction in *S. enteritidis* from the yolk of the shell egg, but again insufficient to cause coagulation of the albumen or the yolk of the shell egg.

Yet another aspect of the present invention provides a method of producing a pasteurized shell egg by heating the shell egg in an aqueous solution of a predetermined temperature and maintaining the shell egg in the aqueous solution for a predetermined time, wherein the predetermined time and the predetermined temperature define a point above the apparent  $F_0$  line of Figure 1, and wherein the predetermined time and the predetermined temperature are insufficient to cause coagulation of the albumen or the yolk of the shell egg. A further aspect of the present invention provides a thermal treatment wherein the predetermined time and the predetermined temperature define a point below the expected salmonella destruction line of Figure 1.

The present invention is also directed to a pasteurized shell egg, wherein the albumen of said shell egg has received a thermal treatment sufficient to cause a 9D reduction in *Salmonella enteritidis* but insufficient to cause significant coagulation. In another aspect of the thermally treated shell egg, the yolk of the shell egg receives a thermal treatment sufficient to cause a 9D reduction in *salmonella enteritidis* but insufficient to cause coagulation.

The foregoing and other objects and aspects of the present invention are explained in greater

-5-

detail in the specification below and the drawings herein, wherein:

#### Brief Description of the Drawings

Figure 1 is a graph of the apparent  $F_0$  line superimposed on the thermal death time curves for salmonella.

Figure 2 is a graph of the thermal curve for a representative thermal treatment received by a shell egg according to the methods of the present invention.

#### Detailed Description of the Preferred Embodiments

The term "shell egg" as used herein refers to poultry eggs, in the shell thereof with the shell essentially unbroken, wherein the egg yolk and the egg white are essentially liquid. Thus it is desired that shell eggs of the present invention contain yolks and whites which are substantially uncoagulated, in contrast to "soft boiled" (i.e., an egg placed in boiling water for three minutes) or "hard boiled" eggs (an egg cooked until both yolk and white are coagulated and solid). While any poultry egg may be used to carry out the present invention (including chicken, turkey, duck, goose, quail, and pheasant eggs), chicken eggs are particularly preferred.

One aspect of the present invention involves the heating of shell eggs in an aqueous solution of a specified temperature for a time sufficient to cause at least a reduction in *S. Enteritidis* (SE) of greater than 5 log cycles (5D). More preferably, the shell egg is placed in aqueous solution wherein the time in the solution and the temperature of the solution impart a treatment to the shell egg sufficient to cause a greater than 7D reduction in SE, and most preferably a reduction in SE of greater than 9D. It is preferred that the treatment of the shell egg be sufficient to cause the reduction in SE in the albumen of the shell



-6-

egg and most preferable that the treatment be sufficient to cause the SE reduction in both the albumen and the yolk of the shell egg. These reductions in SE should be accomplished while retaining the functionality of the shell egg (e.g., maintaining the egg yolk and egg white in essentially liquid form).

For comparative purposes, it is noted that PCT Application No. WO 93/03622 to Cox describes a method of "hyperpasteurization" of shell eggs. As is described in Figure 10 of Cox, relatively severe thermal treatments are expected to be required before salmonella is destroyed. The data points shown in Figure 10 of Cox may be used to construct a line which reflects what would be an expected salmonella destruction line for shell eggs. This "expected salmonella destruction" line is labelled as such and is shown in Figure 1 herein and has the equation  $\log(t) = 8.456 - 0.1183T$ , where  $t$  is time in seconds and  $T$  is temperature in °C. However, these more severe thermal treatments could cause loss in functionality to the shell egg (e.g., partial or complete coagulation of the egg yolk or egg white).

Eggs contain air cells, and the liquid component of eggs have gases such as oxygen and carbon dioxide therein. Cox describes altering the natural proportion of indigenous gases in the eggs being treated by means such as infusing oxygen into the egg or withdrawing gases from the egg. In carrying out the present invention, it is preferred that no such treatment steps be carried out which alter the natural indigenous gases present in the shell egg. Thus, the heating, holding, and cooling steps may be carried out at atmospheric pressure.

In the present invention, the thermal treatment employed preferably defines a point below the expected *Salmonella* destruction line of Figure 1. Furthermore, the treatment of the shell egg should be



- 7 -

insufficient to cause coagulation of either the albumen or the yolk of the shell egg. The methods of the present invention result in a SE negative shell egg having essentially the natural proportion of indigenous  
5 gases.

The method of the present invention involves placing shell eggs in an aqueous solution of a predetermined temperature and then maintaining the shell egg in the aqueous solution for a predetermined  
10 time sufficient to cause the reductions in SE described above. Preferably the volume of the aqueous solution is sufficiently great to minimize the reduction in temperature of the solution by the addition of the lower temperature shell eggs. Optionally, the eggs  
15 may be agitated or the aqueous solution may be circulated about the eggs to facilitate the transfer of heat from the solution to the eggs. Any suitable aqueous solution may be employed, including tap water and water with salt such as NaCl added.

20 After maintaining the eggs in the aqueous solution for the required time, the eggs may be removed and allowed to cool at room temperature. Cooling may be carried out by other means, such as by direct refrigeration, as long as the treatment received by the  
25 shell egg is sufficient to achieve the desired reduction in SE. The heat treatment received by the shell egg after removal from the aqueous solution may be considered in determining the total thermal treatment received by the shell egg, as will be  
30 apparent from the discussion below.

As will be appreciated by those skilled in the art, after thermally treating the shell eggs the shell eggs may be oiled or waxed in accordance with known techniques with a suitable edible oil such as  
35 mineral oil to improve the keeping quality of the eggs.

In selecting the heating temperatures and times to use in carrying out the present invention, any

- 8 -

number of methods may be used, including the equivalent point method of thermal evaluation to determine the total thermal treatment at various locations of the shell egg, including the albumen and the yolk,

5 inoculation studies may be conducted to determine the treatment conditions which yield the desired reduction in SE, or a  $F_0$  value could be determined for the shell egg which results in the desired SE reduction.

Furthermore, times and temperatures may be selected to

10 give differing reductions in SE in different sections of the shell egg. For example, a time and temperature condition may be selected to provide a 9D reduction in SE in the albumen of the egg while imparting a 7D reduction in the yolk.

15 While lower temperatures may be used, in practice, aqueous solution temperatures of greater than about 134° F (or about 56° C) and less than about 140° F (or about 60° C) are preferred and, as discussed above, it is preferred that the temperature of the

20 solution remain approximately constant for the time the shell eggs are heated. Times of from about 20 minutes to about 45 minutes or greater may be selected to achieve the desired reduction in salmonella with shorter times being required for higher temperatures.

25 The specific times and temperatures required may vary with size, age and pH of the shell egg and whether the shell egg has been oiled before or after thermal treatment.

If an equivalent point analysis of the

30 thermal treatment received by a particular portion of the shell egg is utilized to determine the reduction of SE in the shell egg, then the resulting equivalent time and equivalent temperature should define a point above the desired salmonella thermal death time curves such

35 as those shown in Figure 6 of the Egg Pasteurization Manual, which are labelled as such and reproduced in Figure 1 herein.

-9-

If an  $F_0$  analysis is employed in carrying out the present invention, then to assure a sufficient reduction in salmonella such that no shell eggs test positive for salmonella utilizing approved tests for salmonella, such as those approved by the USDA for use in liquid egg processing and discussed in the Egg Pasteurization Manual, then actual time and temperature combinations which define points at or above both the Apparent  $F_0$  line and the salmonella thermal death time curve of Figure 1 should be utilized. As will be understood by one of skill in the art, variations in shell egg physical characteristics, such as size, age, pH, etc., may cause the shell egg apparent  $F_0$  line of Figure 1 to shift.

Shell eggs produced by the methods of the present invention preferably receive a thermal treatment such that the shell eggs have a shelf life of 12, 24 or 36 weeks or more under refrigerated conditions. The term "refrigerated" as used herein means the eggs are stored at a temperature of 4° C.

For storage and shipping, shell eggs of the present invention may be packaged in a suitable container, such as egg cartons or egg flats, constructed of materials such as cardboard or plastic polymer.

Shell eggs of the present invention may be used for any purpose for which raw eggs are currently used, including the table-side preparation of Caesar salads, the preparation of fried eggs, the preparation of hard-boiled eggs, the preparation of other egg dishes, baking, etc.

The present invention is explained in greater detail in the following Examples. These Examples are intended to be illustrative of the present invention, and are not to be taken as limiting thereof.

-10-

## EXAMPLE 1

Salmonella Thermal Resistance

Two experiments were conducted to determine the thermal resistance of SE (Phage type 8) in artificially infected shell eggs and the resulting changes in interior quality due to elevated processing temperatures. During the first experiment fresh shell eggs weighing approximately 62 grams each were obtained from the University research unit. The eggs were dipped in an iodoform solution, excess solution was removed with a cheese cloth and permitted to air dry on sterile plastic egg flats. Each egg was inoculated with  $10^6$  viable cells from a 24 hour Trypticase soy broth culture of SE (phage type 8). The shell was perforated with a sterile blunt 18 gauge needle. A sterile blunt glass needle on a  $10\mu$  liter pipet was used to inject the culture near the yolk surface and the hole in the shell was then sealed with a small piece of aluminum foil and Super Glue. Groups of 36 eggs were subjected to temperatures of 22.2 (unheated control), 56, 56.75 and 57.5°C. Eggs within a temperature-group were subjected to a range of heating time periods ranging from 15 to 45 minutes. The study was replicated in time. Heating was carried out in a shaking water bath equipped with polyethylene egg flats perforated with numerous 1 cm holes to increase water circulation around the eggs.

Immediately following the heat treatment, each egg was broken separately and the albumen plus yolk was mixed for 30 seconds in a sterile Stomacher bag containing 200 ml of lactose broth using a Stomacher Lab - Blender 400<sup>1</sup>. The mixed egg content was incubated in a sterile glass container for 24 hours at 39°C. A representative culture was then transferred to selenite-cysteine broth and incubated for 24 hours at 39°C. The incubated culture was streaked on brilliant

-11-

green agar plates and incubated for 24 hours at 39°C. The suspect colonies were transferred to TSI slants. The second experiment was conducted to evaluate the effect of heating, oiling and storage on interior egg  
5 quality. Four storage treatments of zero, one, two and four weeks were used, each with oiled and non-oiled eggs. The eggs were heated in a water bath at 56.75°C for 36 minutes and 57.5°C for 23 minutes. Eggs were oiled following heat treatment. Thirty eggs from the  
10 control and each treatment were stored at room temperature (22.2°C and 7.2°C).

A group of 14 eggs from each variable was used to determine pH, foam volume, whipping time, foam depth, foam stability, grade and a second group of 14  
15 eggs was used to evaluate Haugh units.

## EXAMPLE 2

### Microbiology

Table 1 presents the results of the thermal treatments on the survival of *S. enteritidis* inoculated  
20 into shell eggs. As temperature increased, the time required to obtain salmonella negative eggs decreased. At 56°C, exposure time required to obtain no positive eggs was greater than 41 minutes. At 56.75 and 57.5°C, exposure times greater than 28 and 23 minutes,  
25 respectively, were required to obtain eggs negative for salmonella. Standard USDA tests for salmonella were utilized.

-12-

Table 1. Number of samples positive after heating at 56, 56.75 and 57.5°C

	Time in Waterbath min.	Temperature of Water		
		56°C •No.-No.+	56.75°C No.-No.+	57.5°C No.-No.+
5	15			12 - 4
	16		12 - 11	
	19			12 - 2
	20		12 - 8	
10	23			12 - 2
	24		12 - 7	
	27			12 - 0
	28		12 - 2	
	29	12 - 3		
15	31			12 - 0
	32		12 - 0	
	33	12 - 6		
	37	12 - 4		
	41	12 - 1		
20	45	12 - 0		

•No.-No.+ . Number of samples heated - number positive

## EXAMPLE 3

Thermal Evaluation

25 Times at temperatures where none of the twelve inoculated eggs were positive, were used in a regression equation to determine the thermal death time curve (TDTC) presented in Figure 1. The equation for the line is:

$$30 \quad \log(t) = -0.1216 \times T + 8.4274$$

where t is the time in minutes and T is temperature in degrees Centigrade. The  $R^2 = 0.86$ .

The above equation may be consider a workable approximation or an apparent  $F_0$  line for *S. enteritidis*  
 35 in shell eggs. The temperature range and times used to obtain the data were selected with the intent of determining if commercially reasonable thermal treatments would have sufficient lethality for

-13-

*Salmonella* sp. It is expected that increasing the number of samples and extending the temperature range would result in some changes in the slope of the line, especially at lower temperatures (Cotterill et al., 1973). Based on concerns for the interior quality and their use in cooking, the practical upper temperature range would probably be less than 60°C. At temperatures in the range of 55 to 65°C, Cotterill et al. (1973) generally found linear TDTC for destruction of *S. oranienburg*. It is anticipated that the  $F_0$  line for other forms of salmonella in shell egg are also linear over that temperature range.

It is established that different strains of salmonella, the type of egg produce, and other environmental conditions will effect the thermal inactivation of salmonella. Shah et al. (1991) presented D values for 17 strains of *S. enteritidis* in whole egg ranging from 13.7 to 31.3 seconds at 60°C. The average D was  $19.2 \pm 5.4$  sec. and was reported to be similar to previous data. Cotterill et al. (1973) and USDA (1969) provide data showing the influence of egg product type, pH, salt, and sugar on the thermal resistance of *Salmonella* sp. When evaluating the thermal resistance of salmonella in intact shell eggs, the location of the bacteria within the egg becomes important. The thermal resistance of salmonella in different egg products is as follows: plain yolk > whole egg or pH 7 egg white > pH 9 egg white (USDA, 1969). Therefore, increased thermal treatments would be required for plain yolk over whole egg or pH 7 egg white or pH 9 egg white.

In this study, the culture was placed in the egg white near the surface of the yolk. The consensus of those actively studying *S. enteritidis* infection of shell eggs is that the bacteria is found in the egg white of naturally infected eggs produced by infected hens (Gast and Beard, 1992; Beard, 1993). The Apparent



-14-

F<sub>0</sub> line was plotted in Figure 1, a redrawing of Figure 6 from the Egg Pasteurization Manual (USDA, 1969). This allows a visual evaluation of the thermal processes applied to intact shell eggs relative to accepted minimal pasteurization processes for liquid egg products.

When comparing the Apparent F<sub>0</sub> line and actual processes to the lines for pH 9 egg white and whole egg or pH 7 egg white, the shell egg processes seem to be more than adequate to achieve reductions of *S. enteritidis* sufficient for an accepted pasteurization process for protection of public health. The pH of the egg whites in this study ranged from 8.4 to 8.6 which is typical for shell eggs the age of those used in this study.

Although natural infections of the yolk are not expected at the time of ovulation, it is clear that under adverse handling conditions, *S. enteritidis* can be introduced into the egg and grow to very high numbers in the yolk (Hammack et al., 1993). At 56.°C (134°F), if the cells were in the yolk, the minimum holding time would be 36.42 minutes for an adequate pasteurization process. Since the apparent F<sub>0</sub> line crosses the USDA yolk pasteurization line at about 134°F, it is therefore preferred that thermal treatments for shell eggs at temperatures above 134°F be selected.

In addition to the F<sub>0</sub> analysis described above, an equivalent point analysis of the time-temperature curve of the thermal treatment imparted to the shell egg may be utilized to determine the total thermal treatment imparted various locations in the shell egg. A temperature probe was inserted into shell eggs in the aqueous solution at various depths into the egg. Temperatures were taken in the albumen at the yolk/albumen interface and in the yolk. These temperatures were taken using a hypodermic needle probe

-15-

model HYP4-16-1-1/2-100-EU-48-RP manufactured by Biomega of Stamford Connecticut. The probe was inserted into the egg through a cork which was glued to the egg and prevented water from entering the egg through the aperture created by the probe. A Daytronic System 10 data acquisition unit was connected through an RS-232 serial connection to a personal computer. Temperature measurements were taken every 5 seconds and recorded. A representative thermal curve for a thermal treatment to the shell eggs is shown in Figure 2. To evaluate the equivalent point for the thermal curve shown in Figure 2, the thermal reduction relationship ( $G_{Ea}$ ) is calculated using the following equation:

$$G_{Ea} = \int_0^{t_{final}} e^{-\frac{Ea}{RT(t)}} dt$$

where  $Ea$  is the activation energy (J/mol),  $R$  is the Universal Gas Constant (8.314 J/mol,K),  $T(t)$  is temperature as a function of time (°K) and  $t_{final}$  is the final processing time (s). This integration process is then repeated for a number of activation energies ( $Ea$ ). Each  $G_{Ea}$  value defines a line of equivalent thermal treatments for that particular activation energy ( $Ea$ ). The intersection of the lines defined by the  $G_{Ea}$ 's is the equivalent point of the thermal process. (Swartzel, 1986, *J. Agric. Food Chem.*, 34:397).

Performing such an equivalent point analysis for the SE negative tests described above results in the following equivalent times and temperatures:

Table 2: Equivalent Point Data

<u>Bath Temp.</u>	<u>Bath Time</u>	<u>Albumen</u>		<u>Yolk</u>	
		<u>Eq. Temp.</u>	<u>Eq. Time</u>	<u>Eq. Temp.</u>	<u>Eq. Time</u>
56°C	45 min.	54.45°C	51.14 min.	NA	NA
56.75°C	32 min.	53.0°C	39.58 min.	53.54°C	38.41 min.
57.5°C	31 min.	54.86°C	38.49 min.	54.33°C	37.47 min.

-16-

From these results an expected reduction in SE may be ascertained or additional thermal conditions predicted to achieve other reductions in SE.

5 Use of the time and temperature relationships discussed above should result in a shell egg which may be guaranteed to be salmonella negative. As used herein salmonella negative means a negative result indicating the absence of harmful salmonella as determined by USDA approved methods of salmonella  
10 testing. This insured salmonella negative shell egg is referred to herein as a pasteurized shell egg.

#### EXAMPLE 4

##### Quality and Function

Quality and functional attributes of shell  
15 eggs heated at 56.75 and 57.5°C with and without oiling are summarized in Table 2. The expected ability of oiling egg shells to maintain fresh egg pH and interior quality is evident. The egg white pH of the oiled eggs is clearly lower than for the unoiled eggs regardless  
20 of storage temperature. The thermal treatments did not seem to have an effect on egg white pH, but did seem to have an impact on interior quality as indicated by the Haugh unit values. For the non-thermally treated eggs, oiling held egg white pH and resulted in higher Haugh  
25 values at both storage temperatures. Oiling the thermally treated eggs appeared to help maintain interior quality if they were stored at room temperature (22.2°C). The thermal treatments alone, provided good protection of interior quality. All  
30 thermally treated eggs regardless of oiling or storage temperature would be considered high A or AA quality grades. There seemed to be less correlation of egg white pH with interior quality than might have been expected. This is particularly so when comparing the  
35 egg white pH and Haugh units of oiled and unoiled eggs. That result suggests the thermal treatments are

-17-

stabilizing interior quality independently of deterioration mechanisms related to change in egg white pH. Funk (1947) claimed that heating shell eggs for 5 to 40 minutes at temperatures of 60 to 43.4°C, respectively, would maintain interior quality without impairing the whipping qualities. However, he did not define quality or whipping qualities.

Table 3: Quality and Functional attributes of thermally treated shell eggs with and without oiling four weeks storage at 22.2 or 7.2°C.

	No Oil	Egg White pH		Haugh Unit		Whip Volume <sup>a</sup>		Whip Time <sup>b</sup>	
		22.2C	7.2C	22.2C	7.2C	22.2C	7.2C	22.2C	7.2C
15	No Heat	9.3	9.2	20	60	1,000	900	40	45
	56.75C, 36 min.	9.2	8.9	78	82	550	650	220	110
	57.5C, 23 min.	9.2	9.1	74	82	750	600	280	130
<u>Oiled</u>									
	No Heat	8.0	8.1	58	70	950	800	45	45
20	56.75C, 36 min.	7.9	8.2	80	80	550	650	190	200
	57.5C, 23 min.	8.0	8.1	81	82	600	700	200	210

<sup>a</sup> Whip Volume in ml.

<sup>b</sup> Whip Time in min.

In this study, the whipping qualities as indicated by whip volume and whip time were adversely effected by the thermal treatments. This indicates that the thermal treatments were substantial and parallel damage that is expected when liquid egg white is pasteurized. Oiling or storage temperature did not seem to have an effect on function of the egg white.

Thermally treated eggs, when broken out onto a plate, appear quite similar to unheated eggs with the exception of some slight opaqueness of the albumen. The normal shape of the thick egg white is maintained and there appears to be the normal amount of outer thin albumen. The yolk membrane may exhibit some weakness. Although yolk indices were not determined, trained observers note some flattening of the yolk relative to unheated controls. The yolk membranes of heated shell eggs did not exhibit any additional fragility over the

-18-

four week storage and seemed to withstand handling for Haugh unit determinations as expected for eggs of the same interior quality.

5       The foregoing examples are illustrative of the present invention, and are not to be construed as limiting thereof. The invention is defined by the following claims, with equivalents of the claims to be included therein.

-19-

CLAIMS:

1. A method of producing a pasteurized shell egg, comprising:
  - heating the shell egg in an aqueous solution of a predetermined temperature; and
  - 5 maintaining the shell egg in the aqueous solution for a predetermined time;
  - wherein said predetermined time and said predetermined temperature provide to the albumen of the shell egg a total thermal treatment described by an
  - 10 equivalent time and an equivalent temperature which define a point above the whites 9D salmonella line of Figure 1 but insufficient to cause coagulation of the albumen or the yolk of the shell egg.
2. The method of claim 1 further comprising
- 15 the step removing said shell egg from said aqueous solution after said holding step.
3. The method of claim 2 further comprising the step of cooling the shell egg after said removing step.
- 20 4. The method of claim 3, wherein said cooling step is carried out at room temperature.
5. The method of claim 1 wherein said predetermined temperature is between about 56 degrees celsius and about 60 degrees celsius.
- 25 6. The method of claim 1 wherein the shell egg is agitated in the aqueous solution.
7. The method of claim 1 further comprising the step of circulating the aqueous solution about the shell egg.

-20-

8. The method of claim 1 wherein said equivalent time and said equivalent temperature define a point above the yolk 9D salmonella line of Figure 3.

9. The method of Claim 1 wherein said equivalent time and said equivalent temperature also define a point below the expected salmonella destruction line of Figure 1.

10. The method of Claim 8 wherein said equivalent time and said equivalent temperature also define a point below the expected salmonella destruction line of Figure 1.

11. A method of producing a pasteurized shell egg comprising:  
heating the shell egg in an aqueous solution  
15 of a predetermined temperature;  
maintaining the shell in the aqueous solution for a predetermined time;  
wherein said predetermined time and said predetermined temperature provide to the albumen of the  
20 shell egg a thermal treatment sufficient to cause a 9D reduction in *Salmonella enteritidis* but insufficient to cause coagulation of the albumen or the yolk of the shell egg.

12. The method of claim 11 further comprising the step of removing said shell egg from said aqueous solution after said holding step.

13. The method of claim 11 wherein said predetermined temperature is between about 56 degrees celsius and about 60 degrees celsius.

14. The method of claim 11 wherein the shell egg is agitated in the aqueous solution.



-21-

15. The method of claim 11 further comprising the step of circulating the aqueous solution about the shell egg.

16. The method of claim 11 wherein said  
5 equivalent time and said equivalent temperature define a point above the yolk 9D salmonella line of Figure 1.

17. A method of producing a pasteurized shell egg comprising:

heating the shell egg in an aqueous solution  
10 of a predetermined temperature;  
maintaining the shell in the aqueous solution for a predetermined time;

wherein said predetermined time and said  
predetermined temperature define a point above the  
15 apparent F<sub>0</sub> line of Figure 1 and wherein said  
predetermined time and said predetermined temperature are insufficient to cause coagulation of the albumen or the yolk of the shell egg.

18. The method of Claim 17 wherein said  
20 predetermined time and said predetermined temperature also define a point above the yolk 9D salmonella line of Figure 1.

19. The method of Claim 18 wherein said  
predetermined time and said predetermined temperature  
25 also define a point below the expected *Salmonella* destruction line of Figure 1.

20. A thermally treated shell egg wherein the albumen of said shell egg received a thermal treatment sufficient to cause a 9D reduction in  
30 *Salmonella enteritidis* but insufficient to cause coagulation.

-22-

21. The thermally treated shell egg of Claim 20, wherein the yolk of said shell egg received a thermal treatment sufficient to cause a 9D reduction in *Salmonella enteritidis* but insufficient to cause  
5 coagulation.

22. The thermally treated shell egg of Claim 20 wherein said shell egg has an essentially natural proportion of indigenous gases therein.

23. A thermally treated shell egg produced  
10 by the process of claim 1, claim 11, claim 17, or claim 20.

1/2

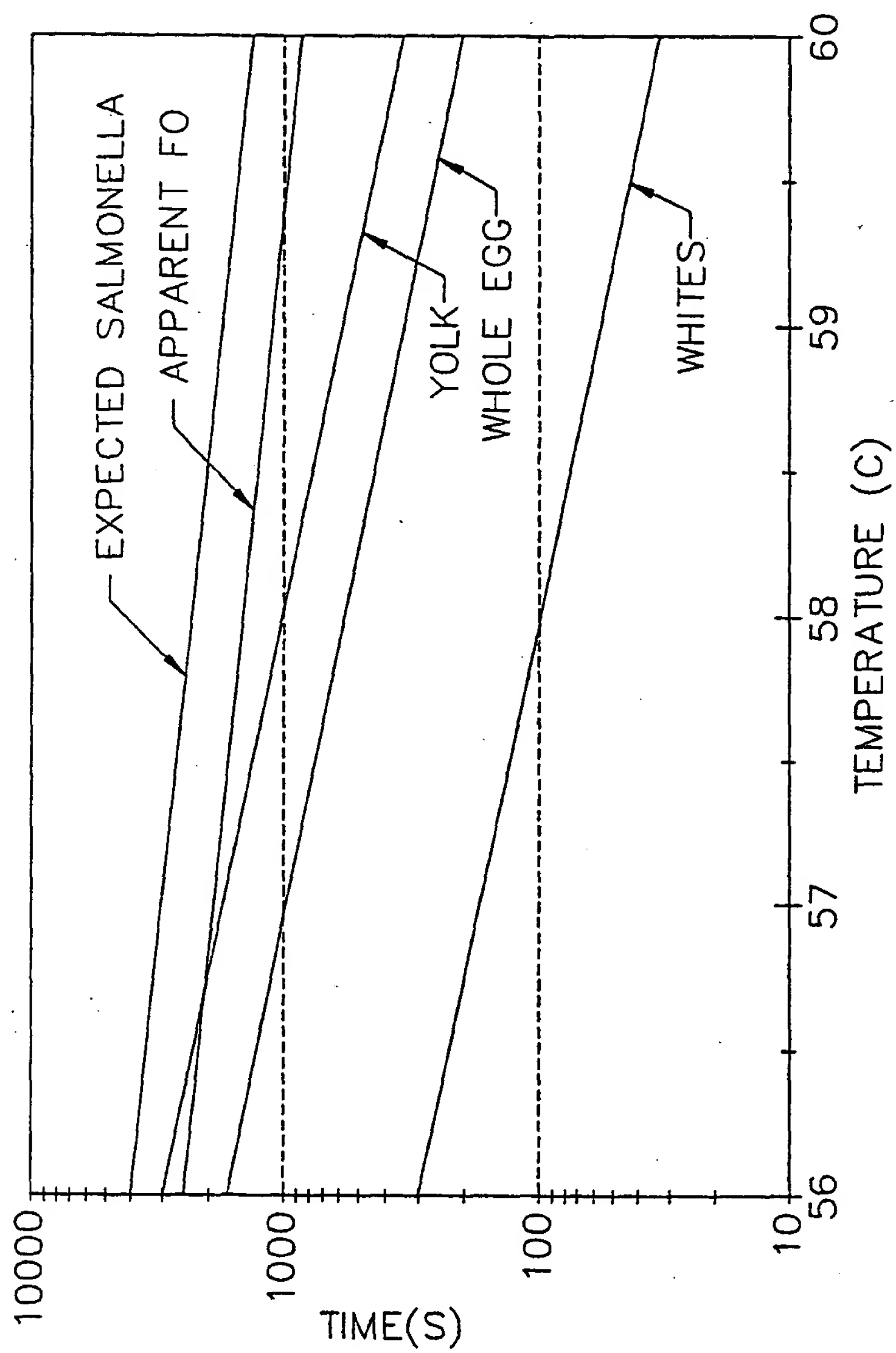
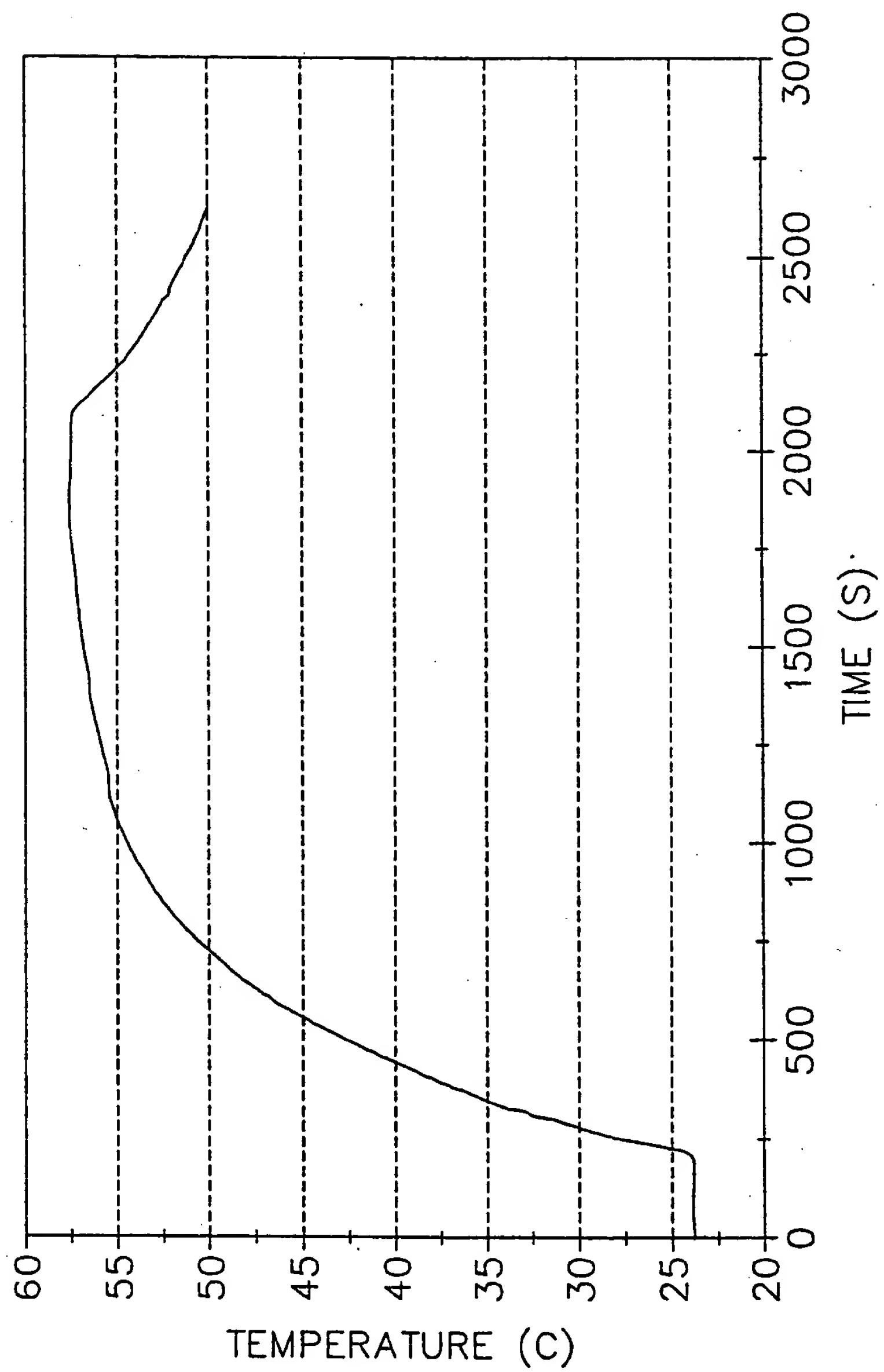


FIG. 1.

2/2

FIG. 2.

A. CLASSIFICATION OF SUBJECT MATTER  
IPC 6 A23B5/005

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)  
IPC 6 A23B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	NL,A,72 454 (NEDERLAND INDUSTRIE VERDELD EI) 15 August 1950  see page 1, line 1-33 see page 1, line 78 - page 2, line 42 ---	1-5, 7-13, 15-23
X	US,A,2 497 817 (C. HALE ET AL.) 14 February 1950  see the whole document ---	1-5, 8-13, 16-23
X	US,A,2 500 396 (S. S. BARKER) 14 March 1950 see the whole document ---	1-23
	--- -/--	

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

\* Special categories of cited documents :

- \*A\* document defining the general state of the art which is not considered to be of particular relevance
- \*E\* earlier document but published on or after the international filing date
- \*L\* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- \*O\* document referring to an oral disclosure, use, exhibition or other means
- \*P\* document published prior to the international filing date but later than the priority date claimed

- \*T\* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- \*X\* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- \*Y\* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- \*&\* document member of the same patent family

Date of the actual completion of the international search

17 March 1995

Date of mailing of the international search report

17. 05. 95

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2  
NL - 2280 HV Rijswijk  
Tel. (+ 31-70) 340-2040, Tx. 31 651 epo nl,  
Fax (+ 31-70) 340-3016

Authorized officer

Guyon, R

## INTERNATIONAL SEARCH REPORT

Int'l Application No

PCT/US 95/00254

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US,A,2 423 233 (E. M. FUNK) 1 July 1947  see the whole document ---	1-5, 9-12, 16-23
A	WO,A,90 09109 (K. SWARTZEL ET AL.) 23 August 1990 see the whole document ---	1
A	WO,A,88 01834 (H. BALL ET AL.) 24 March 1988 see the whole document -----	1

## INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/US 95/00254

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
NL-A-72454		NONE	
US-A-2497817	14-02-50	NONE	
US-A-2500396	14-03-50	NONE	
US-A-2423233	01-07-47	NONE	
WO-A-9009109	23-08-90	US-A- 4957760	18-09-90
		CA-A- 2009429	16-08-90
		EP-A- 0414856	06-03-91
		JP-T- 3502527	13-06-91
WO-A-8801834	24-03-88	AU-A- 8026587	07-04-88



